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Evaluation of the accuracy of the ensemble Kalman filter

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[Introduction]

- Kalman filter (KF) (Kalman 1960) implementation costs much computational resources in the case of the high dimensional AGCMs.
- Because of this reason, it is not able to implement the KF with the recent AGCMs.
- Ensemble Kalman filter (EnKF)(Evensen 1994) approximates the KF using ensemble predictions.

[Introduction]

- Dimension of the barotropic S-model is low (Tanaka 2003).
- We can directly implement the KF with the barotropic S-model.

Purpose

- Evaluation of the accuracy of the KF and the EnKF.

Experimental settings

■ Model

○ Barotropic S-model

$$\frac{dw_i}{d\tau} + i\sigma_i w_i = -i \sum_{jk} r_{ijk} w_j w_k + f_i$$

$$f_i = \overline{f_i} + A_{ij} w_j + B_{ij} w_j^* + \varepsilon_i$$

$$i = 1, 2, 3, \dots, 210 \quad (m = 0)$$

w : complex value

(meridional modes: 1 ~ 10, zonal waves: 0 ~ 20)


○ The dimension of this model is 410.

[Experimental settings]

- Local Ensemble Transform Kalman Filter: LETKF (Hunt 2005)
- Ensemble member : 50, 100, 410, 1000

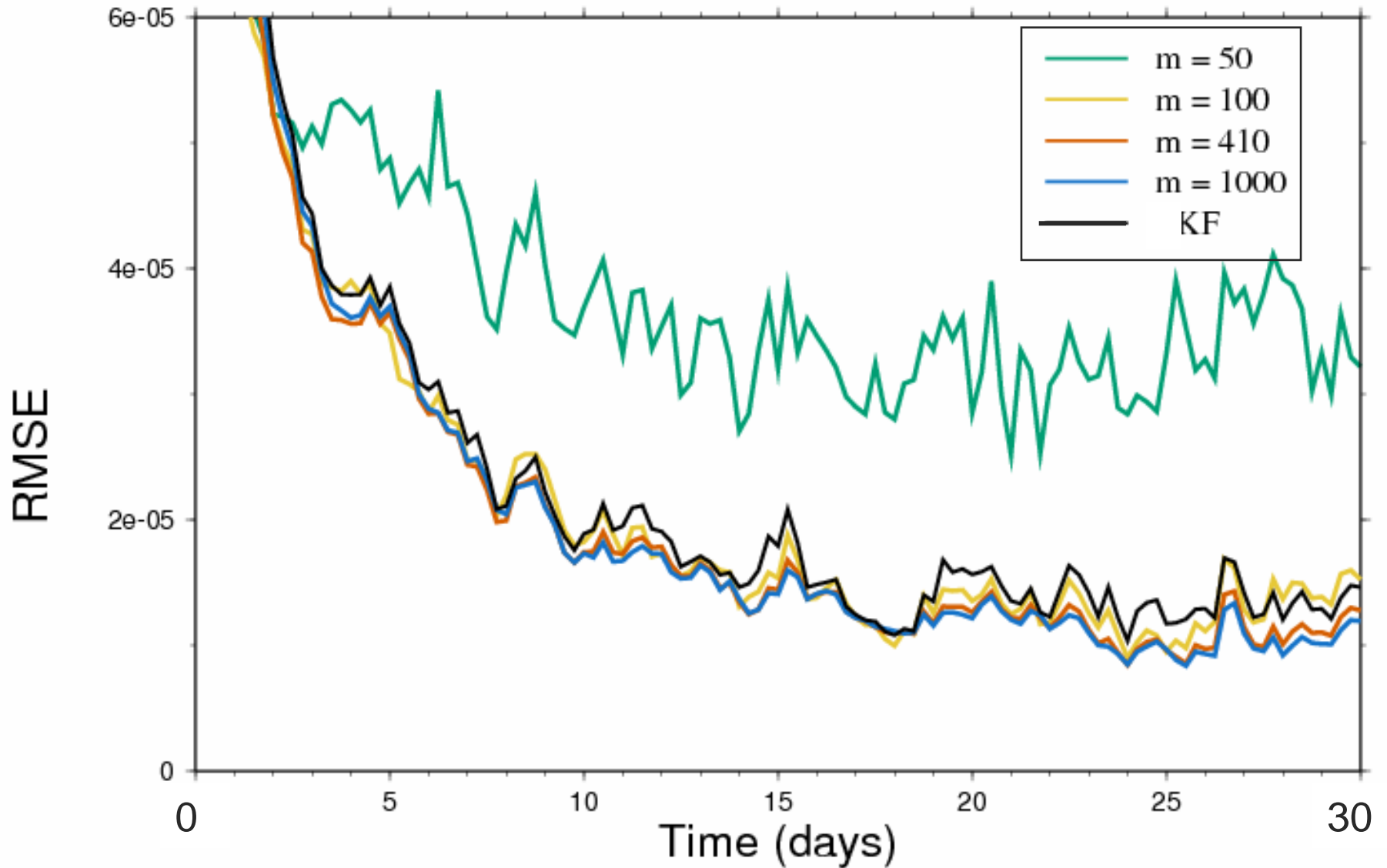
[Experimental settings]

- The KF and the EnKF are implemented in perfect model experiments with the barotropic S-model.
- Observational data = True data + noise
- The KF and the EnKF assimilated observational data to forecast data in every 6 hours.
- The experimental period is from 00 UTC 1 Jan 1990 to 00 UTC 31 Jan 1990.



Results

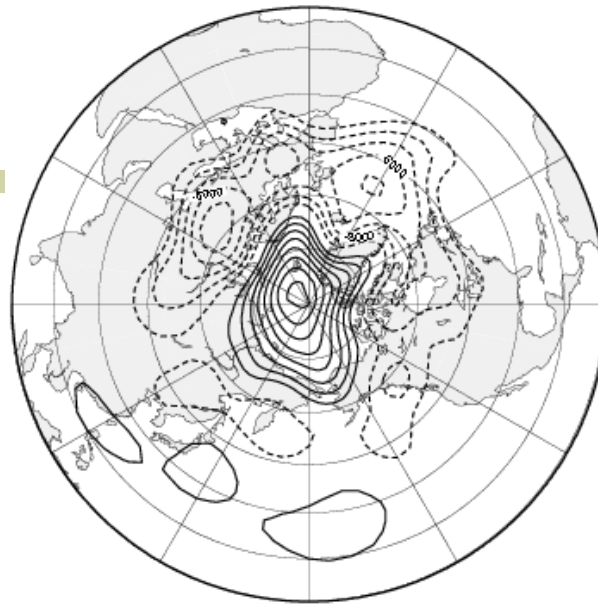
RMSE for EKF and EnKF



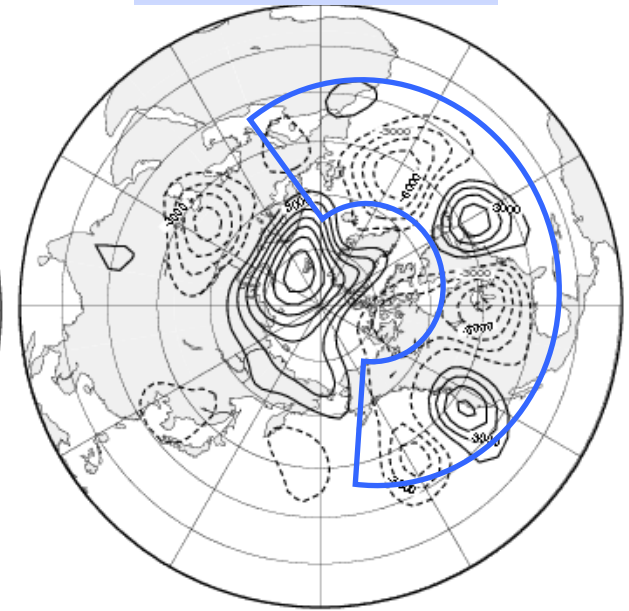
Time series of the RMSE(Root Mean Square Error) for the KF and the EnKF.

First eigenvectors of analysis covariance matrix for the KF and the EnKF.

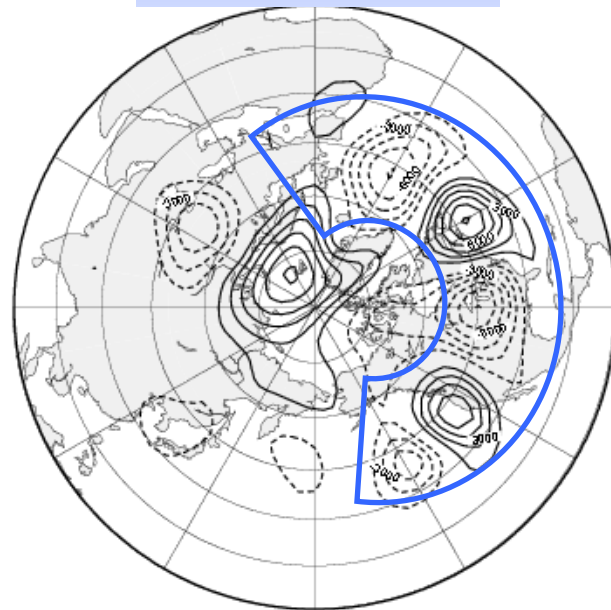
EnKF (m=50)



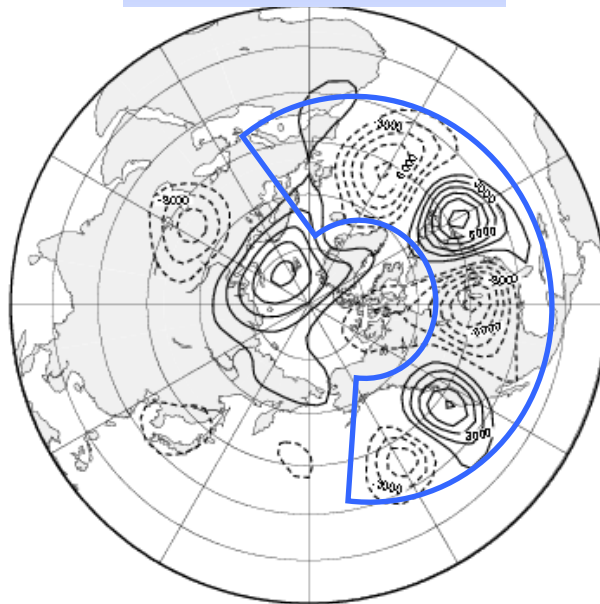
EnKF (m=100)



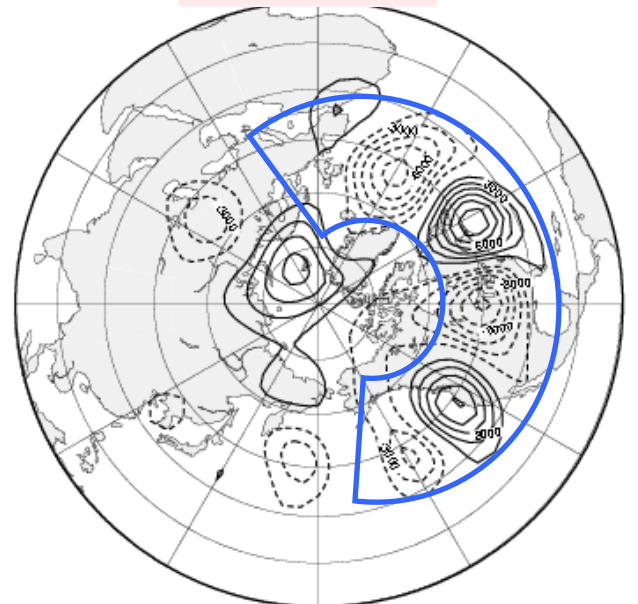
EnKF (m=410)



EnKF (m=1000)



KF



Conclusion

- The accuracy of the KF is almost the same as the 100-member EnKF.
- The EnKF requires more than 100 ensemble members to approximate the KF in the case of the barotropic S model.
- 410 and 1000 members EnKF are more accurate than the KF.
- This seems to be caused by linearization of nonlinear model.
 - Although the KF needs linearization of nonlinear model, the EnKF don't.



Thank you!